

PLANT LOOP AUDITING IN PRACTICE

This paper gives a summary of practical aspects of the Plant Loop Auditing technique, PLA. The PLA technique supplies loop quality aspects/indexes based upon different statistical, energy, spectral, model based and minimum variance methods. Data for PLA evaluation is acquired under normal plant production conditions without any additional excitations! Via the generic approach it is applicable within all industrial application areas, e.g. pulp & paper, metals, building material, food and beverage, chemical, petroleum, offshore ...

The combination of multiple quality indexes, that supervise different characteristics of the plant and the loops, opens new capabilities for early warnings regarding site equipment problems as well as detecting changed plant operational and performance conditions. The supplied indications and reports from the Evaluation Engine is directly useful for production, service and instrumentation management purposes. Evaluation of the quality indexes could be achieved using different advanced technologies. The highest and most advanced technology is accomplished with the assistance of a built-in Knowledge Based Fuzzy engine. The Plant Loop Auditing system is integrated as one part of the multi purpose plant loop optimization tool package PCT Loop Optimizer Suite. More information related to the package is found at (www.pct-world.com)

Keywords: loop auditing, loop performance assessments, loop performance monitoring, plant loop auditing, fuzzy engine, knowledge based, optimal quality control supervision, closed loop analysis.

Introduction

Plant Auditing involves and makes use of loop information and plant raw data acquired under normal plant production conditions via the Automation System. The acquired production data is then treated and included in advanced numerical calculations and evaluations.

Plant Auditing is the umbrella description of techniques described as Loop Performance Monitoring (LPM) or Loop Performance Assessment (LPA) each supplied as an Asset Management technology. These two methods normally have limitations in their usefulness in

practice as they have a limited display of useful features and corrective suggestions. Plant Auditing can better be compared with the technique used before and after a company gets their ISO xxx certificate. This means that multiple aspects are covered in the Plant Auditing process including a defined working structure until the final step of reporting the achieved evaluations.

Plant Auditing methodologies

The very essential aspect of how to reach the final production unit auditing in a structured manner is the methodology of working and aspects related to this. Plant Auditing defines the following working conditions to reach engineering efficiency and ease of use at site:

- One time of data entry
- Production oriented structures defined as a "Batch" of loops
- Handle multiple "Batches"
- Loop Data Container descriptions contain the loop knowledge
- Fully automatic and individual scheduling of all activities for:
 - Data acquisition
 - Evaluation and reporting
- Knowledge zooming of the Evaluation results

The true "one time of data entry" part is a necessary requirement and defines that the user does as little as ever possible when starting Plant Auditing activities. Plant Auditing is normally related to investigations of a large number of loops associated with one or multiple production unit parts of the plant. In the PCT Loop Optimizer Suite, engineering efficiency is achieved via the PCT Engineering Structure Builder product. This product supplies via

5 simple mouse clicks all necessary parts in a Plant Auditing project. This means that a single batch based Plant Auditing project could be started within less than 5–10 minutes. Please note that one such batch could contain 100 loops.

As most plant production units use multiple automation system suppliers this also means that the described methodology and products must support different automation systems and platforms. To achieve this high engineering efficiency it is required that data access is made available via the generic process industry standard designated as the OPC client server methodology. Two data access possibilities are supplied, and supported by the PCT Suite technology:

- OPC DA, direct Data Access in the automation system
- OPC HDA, History Data Access in a Data Historian package or in the automation system itself

Another possibility for similar efficiency for direct Data Access is supplied, and supported by the PCT Suite products,

for use via the ACPLT/KS client server technology.

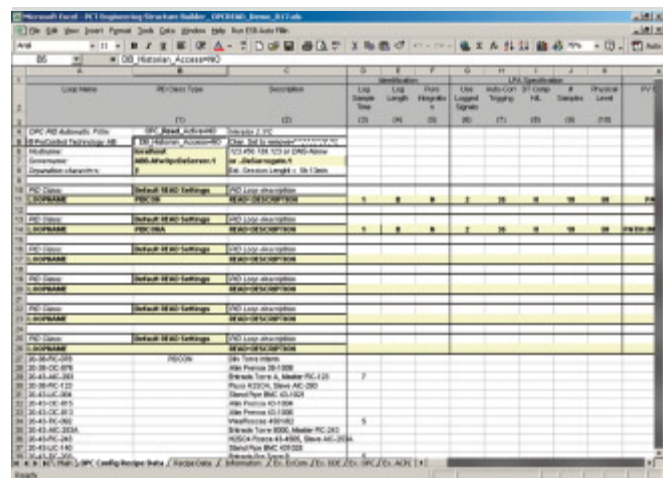
After starting the fully automatic scheduled activities of:

- raw data acquisition
- evaluation and reporting

it becomes necessary to study supplied suggestions and performance evaluation reports. Evaluations must be made available without any kind of additional information supplied by the user. It is also necessary that all evaluation reports supplies directly useful suggestions and indications without making it necessary for the user to feed in knowledge or definitions of any kind.

The results from the evaluations must be presented in such a manner that different type of production people have a presentation which gives the results in a manner focused for their purposes. This means that multiple presentation forms must be made available for the following target groups:

- Executive and site managers level
- Production unit managers level
- Production and automation engineers level



Picture 1: PCT Engineering Structure Builder.

It must also be possible to easily zoom into the next higher level of evaluation condensation or the lower level of details in a straight forward and intuitive manner. This therefore also puts hard requirements on the selected presentation methodology making the results transparent for the user during propagation of the different evaluation reports.

The presented results must be made available in the different reports making it possible to get a straight forward indication what the main outcome indicates, but should also supply necessary background information to make the evaluation outcome more plausible. This is applicable for all levels of evaluation report presentations. With the PCT Loop Optimizer Suite the PCT Loop Audit Remote Evaluation Viewer makes the extended evaluation Levels 4..1 available for all the different target groups while the initial evaluation Level 0 can only be reached directly from within the Evaluation Engine, i.e. the PCT Loop Audit Evaluator.

Executive and site managers level

This level supplies the OPE production unit factor. The OPE abbreviation stands for the Operational Performance Efficiency factor for the selected production unit. The OPE factor is a true Production Unit Optimization Metrics (PUOM) and it supplies one quality index for how well the "Batch" of loops fulfills the production based performance requirements. The OPE factor combines results from the acquired plant raw data and their evaluations and degree of fulfillment of the evaluation requirements on the loop level including the combined results for all loops participating in the "Batch". The OPE factor also takes into account the loop priority selection and the requirements defined for the overall "Batch" evaluation. This makes the OPE factor a true measurement of the actual performance and efficiency of the production unit compared with the standard OEE (Overall Equipment Efficiency) factor

which basically defines if the equipment is used or not. Via the introduction of the OPE factor it is possible to supply one single value (PUOM) to describe the true on-line functionality of a production unit. This level of information is defined as Level 4 and 3 in the hierarchy of knowledge propagation.

On the left side representing the Level 4 information one full production unit, containing a maximum of 100 loops, is represented on one single line. Via 10 such representations 1000 loops can easily be supervised within seconds. On the right side representing the Level 3 information the selected production unit is supervised with background detail information regarding the evaluation results supplied by the knowledge data base in the PCT Loop Audit Evaluator. The Level 3 information is a condensed information of the Level 2 information described further below.

The OPE factor represents the production unit by taking into account the following:

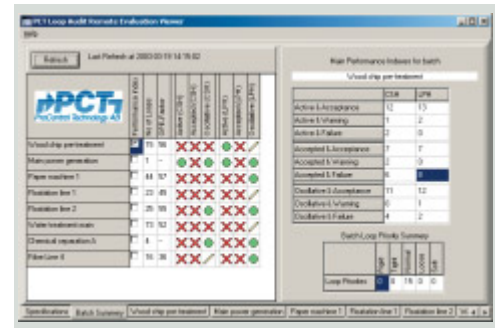
- Availability and degree of activity
- Performance and degree of requirement fulfillment
- Quality of Equipment and stability of function

The OPE factor is calculated as $A \cdot P \cdot Q$ and can as a maximum reach 100%. A very well behaved production unit can reach OPE factors of 80% and higher. During start of a Plant Auditing project production units have shown to have OPE factors of 45 to 60%.

Production unit managers level

In this part Level 2 and 1 evaluation reports are displayed. The left side which represents the Level 2 information shows the evaluation results for the individual loops which forms the production unit, i.e. Batch of loops. Each loop is investigated over two prediction horizons. One over the Long Horizon designated (LPH) and one over the Last Short Horizon designated (CSH) which stands for the Current Short Horizon. The

Picture 2: PCT Loop Audit Remote Evaluation Viewer and the executive report presentation.



evaluation results shows how well the individual loops fulfill the requirements taking into account also the loop defined priority in the production unit. Most loops normally follow the "Normal" priority definition. There are five such loop priority levels. The number of loops for each priority in the production unit is displayed in the highest presentation form of the evaluation, i.e. on the Level 4 display.

On the right side the selected loop in the production unit is displayed in detail. This information represents the Level 1 information. The detailed part shows the main indication of the selected loop as well as the primary additional information. In the table the main performance indexes are condensed over the two prediction horizons. Via the combination of the textual indications and the displayed values in the table the loop performance background is thereby defined accurately. It both ease understanding and explains the final evaluation details and makes them easily accessed for the user.

Production and automation engineers level

The highest detail level is reached via the Batch Summary

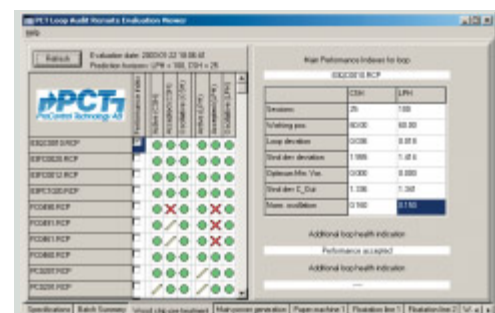
report accessed directly in the PCT Loop Audit Evaluator program. This is defined as Level 0 as it represents the pure results from the knowledge data base. The Batch Summary report is built up of 4 different parts covering different aspects of the evaluation for the individual loops:

- A summary of the Main indications and suggestions for all the loops
- A summary of loops which have changed performance behavior between the last two short prediction horizons
- A summary of the three highest evaluation priorities for the individual loops and the degree of fulfillment of those
- A detailed summary of the performance indexes for the individual loops

The Level 0 also supplies graphical representations of the calculated performance aspects/indexes of the loops. Different graphical presentations are available but the main display is the trend curves of the performance indexes which automatically covers multiple prediction horizons.

The acquired raw data is represented via calculation of 26 different performance aspects/indexes. Not all of those are di-

Picture 3: PCT Loop Audit Remote Evaluation Viewer and the production unit manager presentation.



rectly used by the knowledge data base. Some of the indexes are made available for people who wish to study special effects and investigate conditions outside those directly supplied via the automatic evaluation reports. Via the special selection feature "Condition Based Performance Parameters" it is easy to pick out very detailed operational situations or conditions and study their impact on the evaluation results. Via the "Conditional Parameters" selection methodology only those data sessions which fulfills the conditions will participate in the following evaluations.

Via the possibility to locate reference lines in the trend curves changed loop behavior is further high-lighted for the user. Location of the reference lines can be supplied automatically but manual adjustments are available.

Evaluation principles

PCT Loop Optimizer Suite supplies three levels of automatic evaluation methodologies. The initial level is the Black Box approach which supplies 8 out of the total 11 built-in evaluation scenarios. The Black Box approach requires no interaction from the user and can be used directly after program installation. The Black Box approach is highly recommended to use as it supplies all necessary information for the majority of all production units.

The other two evaluation scenarios are made available if either more process knowledge is supplied or if the reference levels are activated for use. Reference levels can be located on their proper location without having to make use of that extension for the evaluation. The two higher evaluation methodologies are selected per loop.

Most users stay with the Black Box approach even if the package has been designed from the start to supply an extensive amount of additional information and built-in advanced evaluation possibilities.

All calculated indexes are made available in an easily accessible form. This makes it

possible to extend the fully automatic loop oriented evaluations into process specific application knowhow conclusions. Performance indexes supplied by the PCT Loop Optimizer Suite has been based upon a statistically correct background. Using those indexes makes the process based evaluations more plausible and more easily accepted and understood. In those cases, indexes from multiple loops and different parts of the plant can be used. Process specific evaluations requires that process knowledge is available and that process conditions are supervised. Application specific evaluations will thereby supply correct output conclusions if data sessions to use are selected in a manner similar to the methodology used for the built-in "Conditional Parameter" selection. The PCT Loop Optimizer Suite supplies the necessary background information automatically and makes it possible for the user to concentrate the efforts on the application specific evaluation issues. Generation of necessary data to use and the primary evaluations for the production units to reach a continuous high performance can be left for the automatic handling of the PCT Suite products.

How to get Plant Global Performance Optimization

The complicated question "How to get Plant Global Performance Optimization (PGPO) in production efficiency and production quality in the most efficient manner" can be handled and solved with assistance of the PCT Loop Optimizer Suite. The overall goal to achieve is:

- Higher and more continuous and even product quality
- Higher production amounts using the old equipment outside the design specifications

Known constraints for achieving the above primary goals are the reduced amount of resources made available for production handling, i.e.:

- Money
- People

Above conditions sets some very tight considerations to fulfill if a production unit should be able to achieve a global optimization of the production units. Efforts can only be invested on well defined issues that supplies a direct move towards solving the primary goals. This means that production and engineering tools must target to solve above directly, i.e.:

- Suggest where to invest resources to achieve the primary goals
- Supply a continuously updated measurable factor of production functionality

Plant Auditing should be done on all loops at site and especially the loops closest to the control devices such as the valves, pumps, motors, . . . It must supply automatically updated information in a true pro-active and preventive manner for engineering, production and production management.

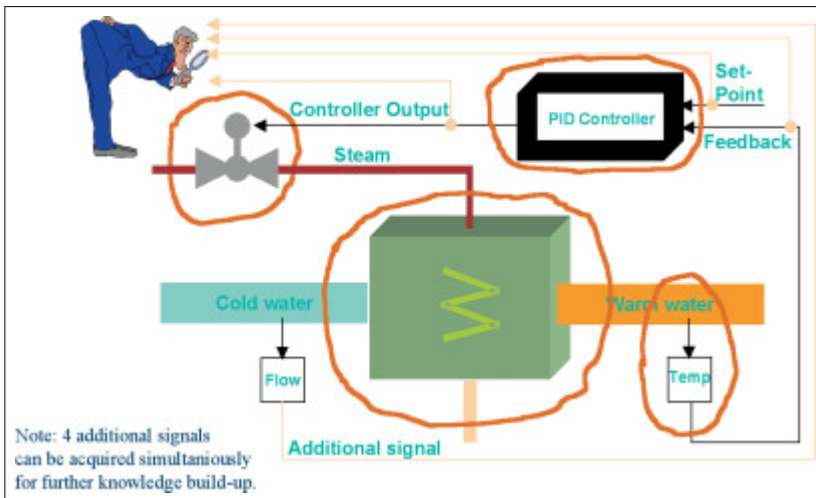
The PCT Loop Optimizer Suite program package has been developed with above in mind by people with long experience in solving exactly those issues for the production industries.

The "Batch" based concept used in any of the PCT Schedulers makes it possible to adapt the performance optimization efforts on units that reflects the parts in production that have functionalities that can be both measured and observed as a unit. The "Batch" based concept is a necessity for achieving PGPO. Each Batch contains all the loops within that functional production unit. Each loop within that "Batch" is analysed in a multitude of manners for different needs of maintenance and early pro-active indications that could need maintenance support. The user does not need to supply any active inputs to start and run such activities as the whole evaluation DataBase is supplied within the PCT Loop Audit Evaluator. This program does the Loop based evaluations and supplies the suggestions/guidelines for how the loop behaves in extensive reports. The textual based reports supplies information for both the engineering departments and the production management at site.

The PCT Loop Audit Remote Evaluation Viewer combines the results from the individual loops within the "Batch" and adds further enhancements to the evaluation and target the presentations for the different users at site. Multiple Batches is supported in the same manner. Thereby each user gets a presentation that opens up the possibilities for active actions, making the production units at site keep their production targets. At the same time it makes the engineers and production management use the same tool. Thereby helping each group to understand the necessity of counteracting negative performance changes in production and understanding the impact on the measureable batch Production Unit Optimization Metrics, i.e. the Operational Performance Efficiency (OPE) factor. Each Batch is displayed in one line in the "Batch Summary" presentation form, i.e. the executive report presentation

One batch could condense the results from max 100 loops for a production unit. In the "Batch summary" figure, also designated the executive report presentation, 201 loops are displayed and they are divided in 8 batches, i.e. 201 loops are displayed in just 8 lines and Evaluation of those loops would have taken max 2 second for production management to understand if further actions are needed in any of the connected production units.

A quick view indicates that most of the batches could be improved. This is partly due to the indications via the green led, the red cross and the yellow diagonal indicators. The OPE factor itself directly indicates that further improvements could be achieved. It is necessary to do adjustments/maintenance at site as the OPE factor is in the range of [36; 57]. A batch of loops should have an OPE factor around 70-75 and then production would be considered to be good. This also means that only green leds would be seen for the Long Prediction Horizon (LPH), i.e. the three right-most columns on the left side.



Picture 4: The Loop component objects under advanced supervision by the PCT Loop Optimizer Suite products.

The mid European representative company for the PCT Loop Optimizer Suite product is Leikon GmbH and they can be reached at www.leikon.de or via phone: +49 2407 95173 31 and responsible contact person is Dr. Udo Enste.

levels of permanent OPE factors are achieved when plant maintenance and automation engineers have been appointed these functions as their primary responsibility. Via the evaluation reports, corrective actions can be focused on the correct loops to reach maximum return on the invested time for the production unit functionality.

The ease of interpreting the impact on the production unit for different levels in production management has made it easier to initiate and execute corrective actions. Via the strict methodolo-

The OPE factor is a true measurement of the achieved production quality as it measures the performance of the loops to fulfill their different requirement targets, i.e. a true Production Unit Optimization Metrics.

Each Batch which is displayed in one line in the Batch Summary form can be studied in further detail in the batch specific detailed loop presentation form.

Evaluations and reporting is based upon the requirement specification and the built-in Knowledge DB supplied in the PCT Loop Audit Evaluator.

The user can influence some key parameters in the Evaluator but need not change anything. This means that full benefits of the Knowledge DB and the requirement specifications can be done directly without any changes from the user, e.g. the Black Box approach.

Eight direct indications with supporting suggestions is automatically supplied and covers a variety of aspects of below four main loop components:

- The control object and measurement devices
- The PID Controller
- The physical Application Process
- The Surrounding Application Process environment

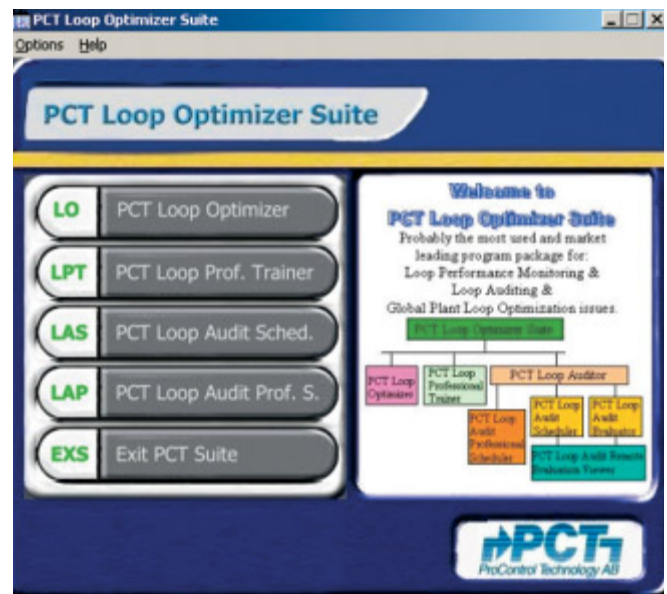
The answer to the question "How to get Plant Global Performance Optimization (PGPO)" has been made very straight forward and very easy to follow due to the very structured approach supplied with the PCT Loop Optimizer Suite product.

- Select those production units, i.e. Batches, with the lowest OPE factor
- Start targeting the Loops within the "Batch" with the highest priority order, i.e. to get a Green Light, on all three primary investigation conditions/targets and to do so for both Prediction Horizons
- The results are updated continuously via the scheduled Evaluation periods. This means that the selection what to work with has become very easy. At the same time both the feedback and documentation is supplied automatically.

Summary and conclusions

Results and data displayed in the different Evaluation report levels have been supplied from different process industries such as pulp and paper, metals, mining and mineral, chemical and petro-chemical. It also covers different types of loops such as: flow, pressure, temperature, consistency, pH, level, ...

The Production Unit Optimization Metrics (OPE factor) have changed from the initial level of 45 to 60% at the start of the Plant Auditing period to reach a new more permanent level of



Picture 5: PCT Loop Optimizer Suite, main interface (all pictures: ABB).

65 to 75%. In some cases, the OPE factor have reach even higher levels, i.e. 83 to 86%. This has been achieved after the production unit has strictly followed and executed the corrective suggestions supplied in the evaluation reports. The higher

how to execute a Plant Auditing project makes it easy to supervise and follow also from a more generic perspective.

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